15:02:44 OCA PAD AMENDMENT - PROJECT HEADER INFORMATION 02/22/93

Active

Project #: E-27-615 Cost share #: Rev #: 2
Center # : 10/24-6-R7124-0A0 Center shr #: OCA file #:
Work type : RES
Contract#: STD. AGREEMENT Mod #: ADMINISTRATIVE Document : AGR
Prime #: Contract entity: GTRC

Subprojects ? : N CFDA:
Main project #: PE #:

Project unit: TEXT ENGR Unit code: 02.010.130
Project director(s):
OLSON L H TEXT ENGR (404)894-2534
J L DORRITY TE

Sponsor/division names: MONSANTO COMPANY /
Sponsor/division codes: 212 / 030

Award period: 910201 to 930228 (performance) 930228 (reports)

Sponsor amount	New this change	Total to date
Contract value	0.00	69,670.00
Funded	0.00	69,670.00
Cost sharing amount		0.00

Does subcontracting plan apply ?: N

Title: IMPROVEMENT IN SLIVER COHESION UNIFORMITY

PROJECT ADMINISTRATION DATA

OCA contact: Anita D. Rowland 894-4820

Sponsor technical contact

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Sponsor issuing office

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L. ROSS JENKINS
MONSANTO CHEMICAL COMPANY
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Security class (U,C,S,TS) : U
Defense priority rating :
Equipment title vests with: Sponsor GIT

ONR resident rep. is ACO (Y/N): N
supplemental sheet

Administrative comments -
NO-COST EXTENSION THROUGH FEBRUARY 28, 1993 AUTHORIZED BY THE SPONSOR.

SR426

GEORGIA INSTITUTE OF TECHNOLOGY
OFFICE OF CONTRACT ADMINISTRATION

NOTICE OF PROJECT CLOSEOUT

Closeout Notice Date 03/19/93

Project No. E-27-615   Center No. 10/24-6-R7124-0A0

Project Director OLSON L H   School/Lab TEXT ENGR

Sponsor MONSANTO COMPANY/

Contract/Grant No. STD. AGREEMENT   Contract Entity GTRC

Prime Contract No.

Title IMPROVEMENT IN SLIVER COHESION UNIFORMITY

Effective Completion Date 930228 (Performance) 930228 (Reports)

Closeout Actions Required:	Y/N	Date Submitted
Final Invoice or Copy of Final Invoice	Y	
Final Report of Inventions and/or Subcontracts	N	
Government Property Inventory & Related Certificate	N	
Classified Material Certificate	N	
Release and Assignment	N	
Other	N	

CommentsEFFECTIVE DATE 2-1-91. CONTRACT VALUE $69,670.

Subproject Under Main Project No.

Continues Project No.

Distribution Required:

Project Director	Y
Administrative Network Representative	Y
GTRI Accounting/Grants and Contracts	Y
Procurement/Supply Services	Y
Research Property Managment	Y
Research Security Services	N
Reports Coordinator (OCA)	Y
GTRC	Y
Project File	Y
Other HARRY VANN-FMD	Y
FRED CAIN-OOD	Y

E21-615

Improvement in Sliver Cohesion Uniformity

Report to

Monsanto Chemical Company
Fibers Division
P. O. Box 2204
Decatur, AL 35602

L. Ross Jenkins, Technical Monitor
S. Paul Wallace, Technical Monitor

from

Georgia Institute of Technology
School of Textile & Fiber Engineering
Atlanta, GA 30332-0295

J. Lewis Dorrity
L. Howard Olson

March 9, 1993

Table of Contents

Introduction

In mid 1990 Ross Jenkins and Paul Wallace of the Monsanto Decatur Plant began discussions with Lew Dorrity and Howard Olson of Georgia Tech regarding the problem of Cohesion measurement. Discussed in particular was the laborious and costly procedure of cohesion testing. Testing at the Decatur Plant of Monsanto included the following steps:

- Sampling tow
- Cutting into staple
- Processing in the lab to make sliver
- Testing cohesion on the Rothschild Tester

All of these procedures consume a lot of time and are expensive to run, but the procedure is the only known standard means of testing cohesion. Perhaps the most critical point in using this test method is the long delay time between sampling raw materials and obtaining results. The Cohesion Test is highly variable and the sample run is very small. There is some concern about how representative the sample was of the lot being produced. When starting a new lot on a spinning machine, a fast and reliable test is needed to see whether the machine needs any adjustment before continuing the run. Long feedback time results in poor process control capability.

The interfiber cohesion is critical to processes for yarn production, particularly those steps where carding or drafting takes place. The most important factors in determining fiber cohesion for a particular fiber are fiber finish and crimp. While finish is applied in the spinning process, the crimp is applied in both the spinning and the recrimping processes. The cohesion at intermediate stages is not now monitored routinely.

To address this question a research proposal was made. The statement of work in the proposal to Monsanto was stated as follows:

> "The principle task is to look at the production line at Monsanto and determine whether device(s) in line can provide information about changes in the production line in a real time framework or at least much shorter time than is currently required to detect product variance. The fiber properties of interest are those which affect cohesion particularly. Possible candidates for indicating changes to cohesion are scroop and denier.
>
> Appropriate methods will be selected to achieve the task goal.

Obviously acoustic emissions, perhaps at a trumpet style guide, is one candidate. A device is proposed which would cause filament-to-filament motion in a non-destructive manner which is monitored acoustically and analyzed electronically. Also, light scattering from the fiber's surface, contact type friction measurement, and near IR are possibilities."

The ensuing research led to the design of a new test method and apparatus which is:

- low cost
- fast
- less variable than previous tests
- indicative of changes in fiber cohesion

Design of an Improved Test

Acoustic (scroop)

Since there are those who can distinguish between the sounds emanating from the rubbing of synthetic fibers to distinguish fiber type, one might expect that there may be information in that sound which would relate to the cohesion (frictional) properties of the fiber. A number of techniques have been investigated which could generate sound including:

1. Rubbing two sections of tow together while under some tension in a bow apparatus.

2. Manually rubbing fibers together in an acoustic chamber.

3. Mounting samples in a cylindrical chamber and analyzing the sound spectrum.

4. Using the Monsanto provided Compression Tester to produce a sound signal.

In the first case when under tension, the crimp was modified which certainly affected one of the prime factors in determining cohesion. The magnitude of sound in this method was low and difficult to repeat.

In the second case, it was very difficult to reproduce the experiments. Repeatability is, of course, very important to test reliability.

The third case was investigated to increase repeatability and reduce tension requirements, but the magnitude of sound was not sufficiently large when compared with ambient sounds for machine based discrimination.

Finally, the compression tester was found to have excessive background noise for purposes of this test.

Thus none of these methods successfully produced results which were usable in predicting the cohesion properties of the fiber. In all cases the magnitude of sound was very low. As a result, the acoustic methods were compared with the Friction tests being done in parallel and found the friction test to be superior.

Friction Measurement

A second and more direct method of of measuring cohesion properties of fiber was to directly measure the frictional force generated while forcing two sections of tow to move against each other with a known force pushing them together. The design concept is shown in Figure 1.

This figure shows the tow sections mounted horizontally with a known mass acting on a known area. While the upper section is held stationary by the load cell, the lower section is pulled beneath it by a tensile testing apparatus. A typical force versus time curve is shown in Figure 2.

A decision was made to concentrate the efforts of this research project on this method. Although some conceptual techniques for on-line measurement of these properties were developed (See Appendix) the off-line method needed to be verified. The time to measure frictional forces is just a few minutes as compared to hours with cohesion tests. The test could be made simple enough to be run on any shift with little skill being required.

To keep costs down and yet prove the principle, a crude wooden apparatus was fabricated and attached to a Testron tensile tester in the Physical Testing Lab at Georgia Tech. Initial results were very promising and were shared in visits to the plant. Monsanto personnel agreed to have a more substantial unit fabricated in the plant metal shop. The shop made a unit for the plant and another for Georgia Tech. The only difference was in the mounting of the load cell. While the load cell at GT is mounted directly on the main bed, the plant unit required a cabling system to connect the tow to the load cell mounted in its normal position on the Instron. This cable system can cause some problems in measurement and certainly forces the operating technician to take special care in resetting the unit before each test.

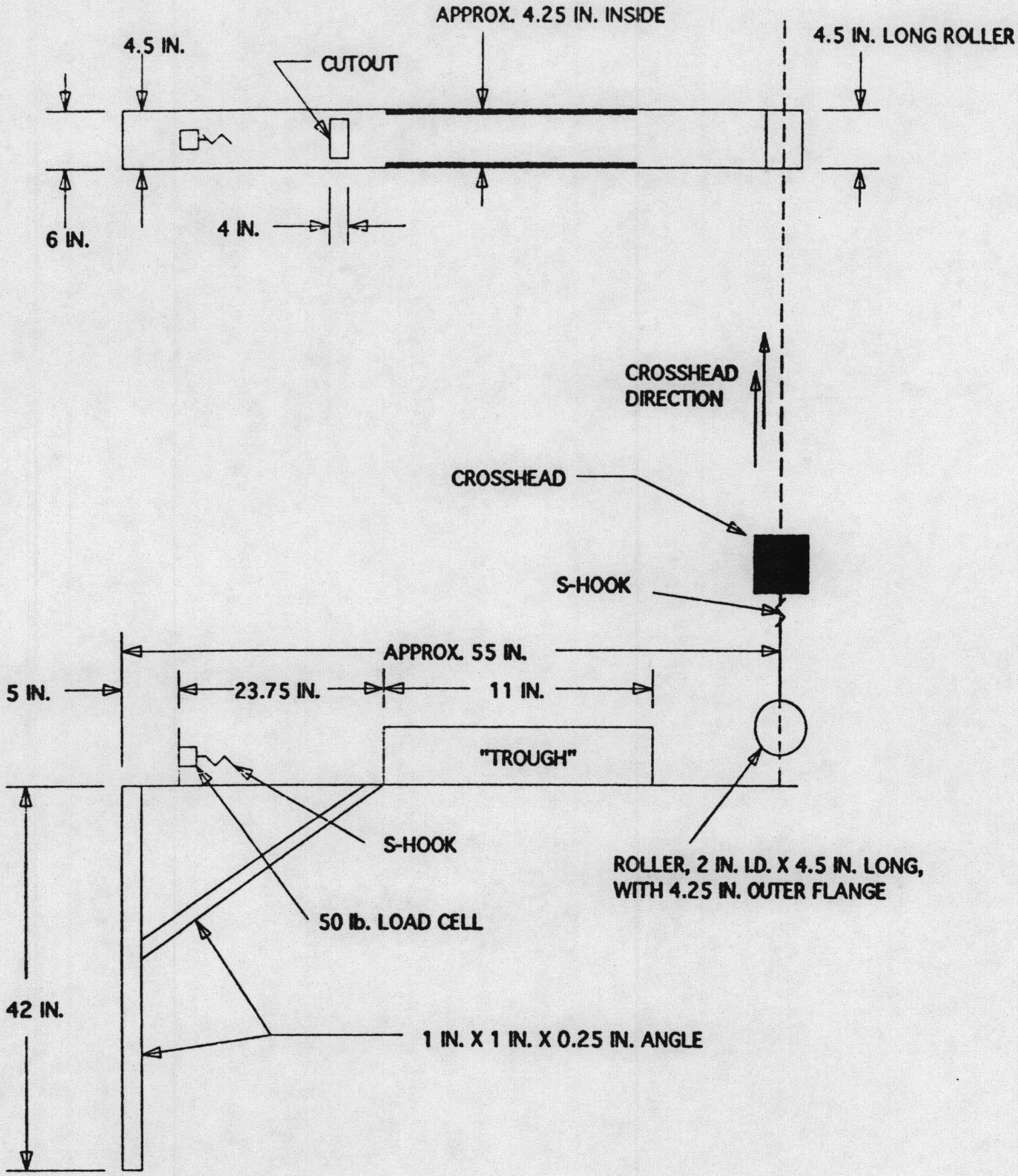


FIGURE 1. Modified Testron: dimensional analysis.

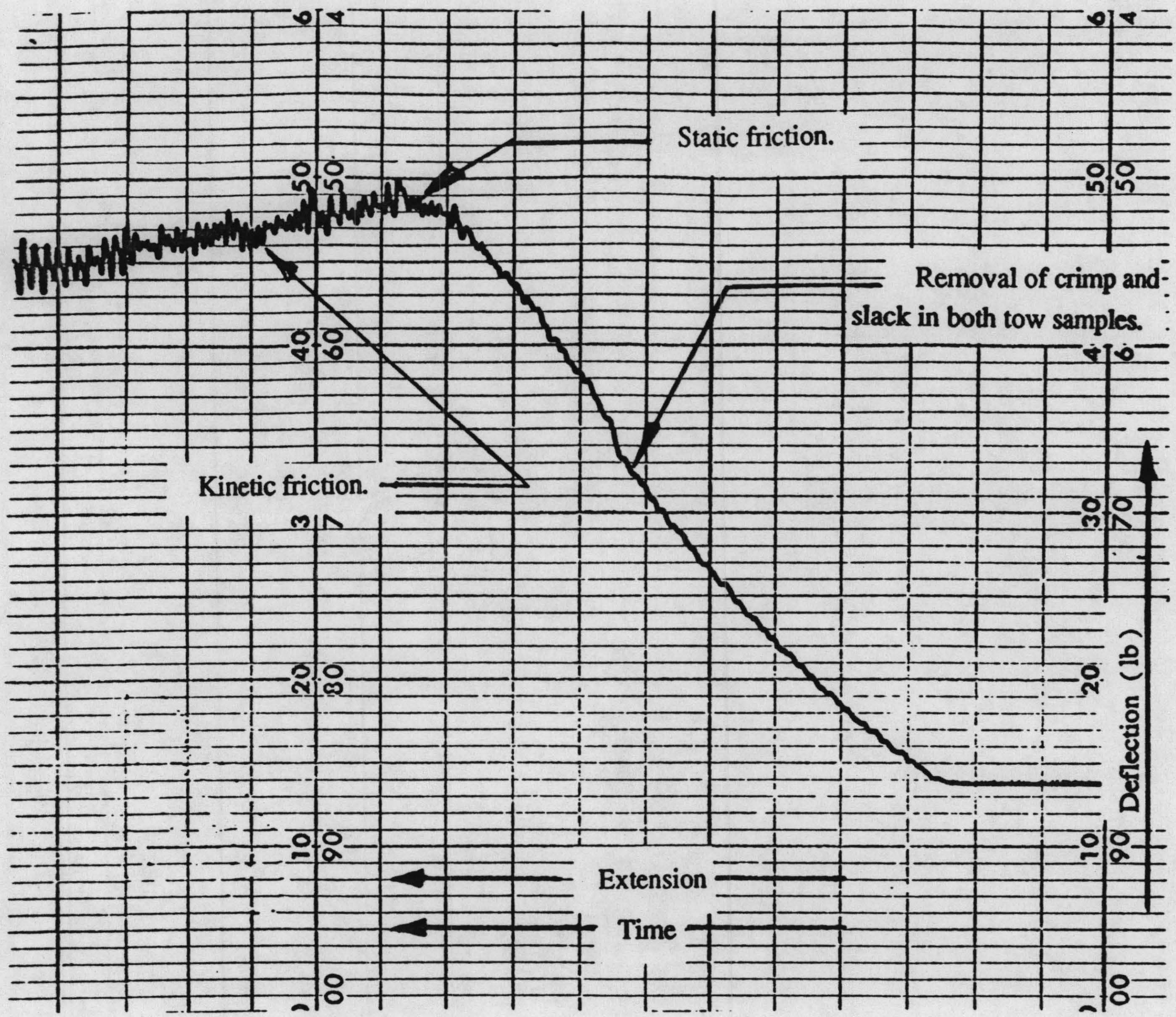


Figure 2. Typical frictional force curve.

Testing at Georgia Tech

Numerous students were involved in testing while doing work for both Senior Projects and Masters Degree Projects. Initial tests were run with 3 kg mass on an area of 300 cm^2. Many tests were run on samples provided by Paul Wallace. Along with the tow, data was provided on cohesion measurements. Initial runs on the Georgia Tech prototype were most encouraging and the correlation was sufficient to justify more extensive testing.

The Monsanto fabricated unit was installed at Georgia Tech and was found to be a great improvement. Since the initial testing had yielded forces in the 1 to 3 pound range, the decision was made to replace the 500 # load cell with a 50# load cell to insure greater accuracy on the low end of the scale.

Mass Effects

Many tests were performed to investigate the effects of changing the mass value to be used in the test apparatus. Central to the investigation was to determine the variability of the tests with different masses. Long lengths of continuous tow were provided by Monsanto and tests were run sequentially cycling through three different mass units repeatedly. The data were analyzed statistically.

Denier Effects

Samples of various denier were provided by the plant and test variability was investigated by Jennifer Taylor and Lydia Henderson. Similar frictional force levels were seen with a wide range of denier in the samples.

Short term variability

The short term variability of the material was checked by repeated testing of long lengths of continuous tow. The results indicated that there is significant variation from yard-to-yard (as much as ±1.95 mtf). This is caused by conditions at the stuffer box crimper.

Decatur Plant Testing

The plant agreed to collect a large number of samples of tow as the routine testing for cohesion was performed. The data sent to GT included cohesion test values and friction test data done at the plant.

After a sufficiently large data base was generated, least-squared-error fit methods were used. The data from the two methods did seem to track trends, but local differences were apparent. Complicating the analysis effort was the fact that both the Cohesion test and the Friction test have variability and the fiber tested cannot be the same. Since the local variations in crimp are significant, this added to the difficulty in comparing test methods. Normally regressions are performed with one variable being precisely known and the variability of the dependent variable being handled statistically. This is not the case here and standard techniques did not work well.

Correlation method:

Initial work toward prediction of cohesion was done using linear least-squares regression methods. The data is bivariate i.e. both variables are imprecisely known. Also the data shows that the Cohesion test is more variable than the Friction test. The correlation method is based upon the comparison of statistical frequency distributions. Assuming a linear relationship between the two in the form:

$$\mathbf{MTF = A * Force + B}$$

where: A and B are constants, MTF is a number comparable to cohesion (CCS), Force is an average of three or more measurements. MTF stands for Monsanto Tow Friction.

The idea is to measure the mean and standard deviation of the two distributions of force and cohesion and multiply the s_{force} by the constant A to make the product equal to $s_{cohesion}$. Then the constant B is added to make the mean of MTF equal to the mean of the CCS. This is a simple, straight forward method of transforming the frictional force values into numbers comparable to cohesion. The results were good and explained the variation better than did the normal least-squared-error methods. Also noted was that the cohesion test sometimes gave large deviations from the normal which were not noted in the friction test. One must remember that a minimum of three tests are run for the friction test and the average is used, whereas only one test is run for cohesion. The amount of fiber tested is much greater in the friction test as compared to the cohesion test.

The equation for the product 060180 was as follows:

MTF = 3 * Favg - 4.6 ; where Favg is the average of 3 samples

A plot of typical data comparing CCS from the cohesion test and MTF (Monsanto tow friction) from the friction test is seen in Figure 3.

One rather surprising result was that the equation derived for 060180 was a fairly good equation for other products. Some adjustment was needed for accurate results when the fiber characteristics were very different.

Computer Simulation of Random Behavior:

In order to demonstrate the reasonableness of the statistical approach used in lieu of the usual least squares linear regression, we set up a spreadsheet as shown in the Appendix. The approach was to use a value for X in the range of the frictional force Favg values and compute a Y value from the linear relationship

$$Y = A\,X + B.$$

Next two columns of random numbers were generated from normal distributions which were in the range of variation observed in F and CCS respectively. These random numbers were then added to the X and Y values to randomize them. Scatter plots and time plots were generated and the standard regression done. In addition the technique of calculating A by:

$$A = \sigma_y / \sigma_x \quad \text{and} \quad B = \mu_y - A\,\mu_x$$

Comparisons of many trials of different sets of random numbers showed that the prediction of the true A and B from the original calculation were closer in the latter case than the former. The justification for doing this is shown in a book by Miller & Freund " Probability and Statistics for Engineers". Here the authors discuss the problem of not knowing the precise value of either X or Y and the relationship if linear can be predicted by the relationships as given above when the standard error of the estimate is small compared to A σ_x . This is true for our data sets.

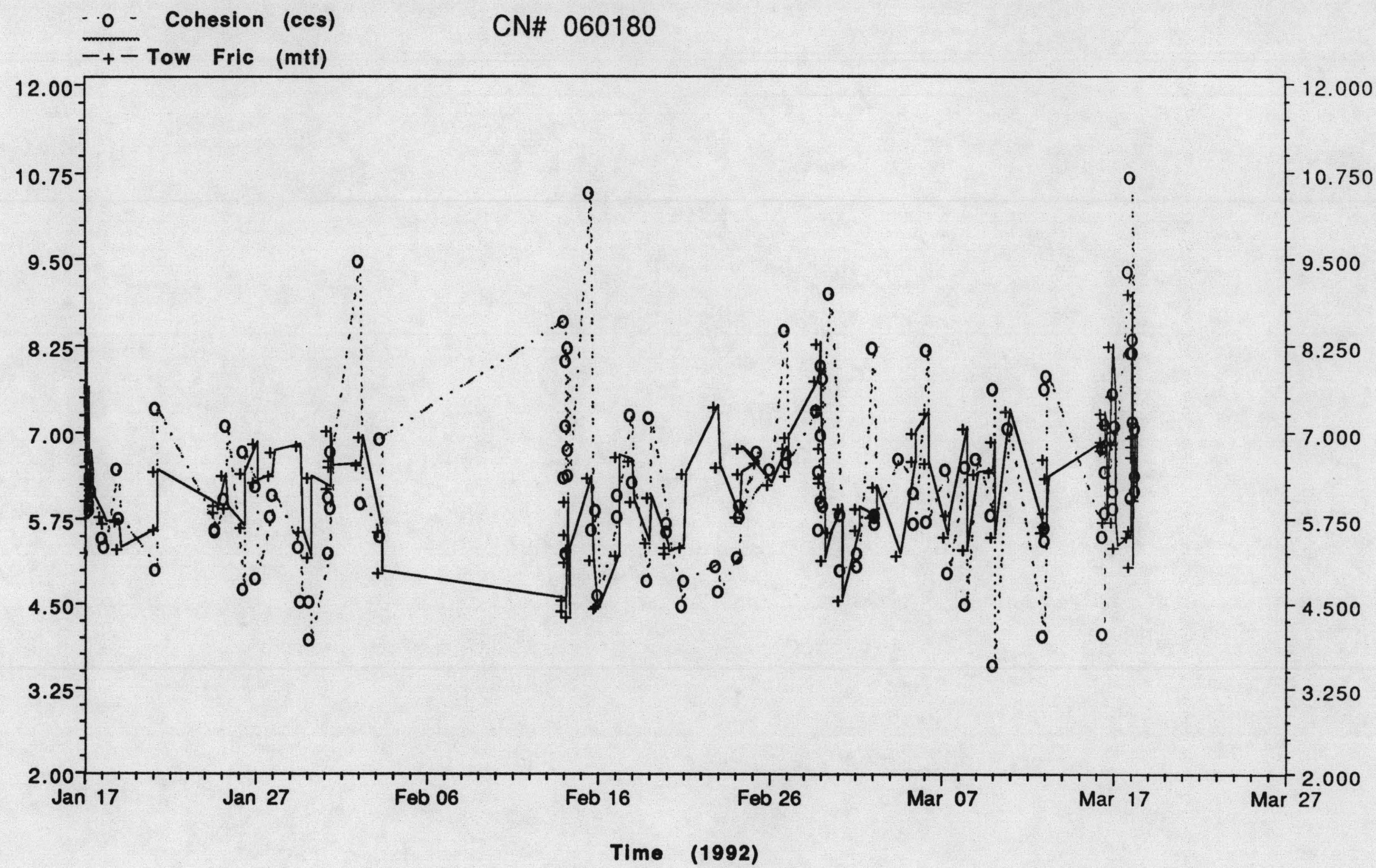
The example in the Appendix uses A=3 and B=-5 which are approximately the values found for the actual data. The predictions are shown below:

	Actual	LS pred.	Correlation
A	3	2.41	3.0
B	-5	-2.35	-4.4

This simulation does not include the random effect of the actual differences in tow measured and the yard-to-yard crimp variation is significant as reported earlier. The assumption above is that the samples tested by the two methods are essentially the same and the variation is due to test variability of the two tests. Including the tow sample differences would make the comparison even more different. This points out the obvious advantage of using more tow in multiple samples and working with averages.

Comparison of the histograms of CCS and MTF show striking similarities when the above formula is used. This is clear evidence that the relationship is valid and useful for control purposes.

Fig. 3 MTF - CCS Overlay



mtf = 3 * Favg - 4.6 mtf relates to ccs

Plant Tests

After extensive testing and data analysis at GT proved most promising, the research team recommended that one spinning machine be designated for extensive trial of the friction test reliability. The data available indicated that the cohesion test variability sometimes led to process adjustments which were in effect reversed after the next test results were obtained. The results also indicated that the friction tests were less variable than the cohesion tests. Most notable was the absence of the large excursions in data from the friction tests seen in the cohesion data. Supporting this is the data comparing bale data against MTF. These data show that the variability of the bale cohesion data conforms more closely to friction data than the sample cohesion data.

A two-week period in which one spinning machine was designated to be left without adjustment unless serious errors were suspected from the cohesion testing. The friction tests were to be done frequently and those data used to judge the quality of cohesion.

Results: To date the GT research team has been unable to obtain the results of the test except that the machine was not adjusted during the test period, that no problems were encountered and that the friction test indicated no problems. Analysis of the data is necessary before making further recommendations regarding the wide implementation of this technique.

Conclusions:

Data analysis indicates that the friction test is a reliable measure of frictional properties and is a more reliable indicator of suitability for processing. Further plant trials are recommended. The cause of a change in friction measurement may be distinguished between finish and crimp by testing the frictional characteristics with different test masses.

The method of handling the correlation of data when both variables have significant uncertainty applies to other situations when a linear relationship exists between the variables.

Acknowledgements:

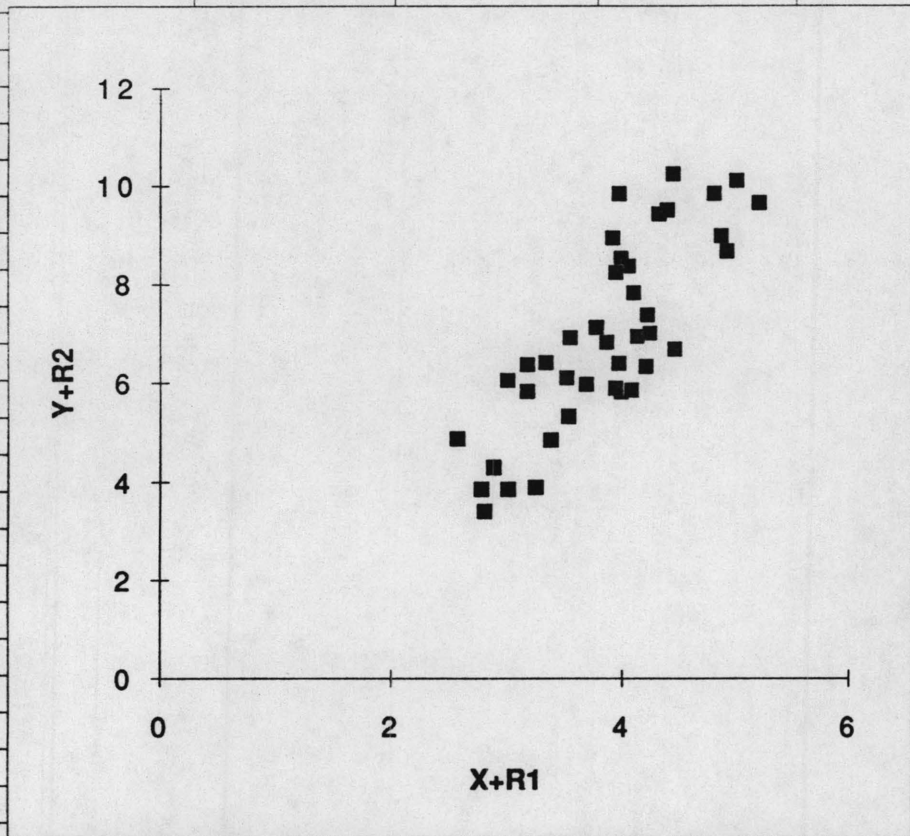
The research team wishes to acknowledge:

- the support of Ross Jenkins in providing funds and guidance on the project.
- the guidance and assistance of Paul Wallace in providing samples and data for analysis and coordinating the project.
- the work of graduate students Dana Kelly and Jennifer Taylor.
- the work of undergraduate students Donna Alexander, Vanessa Hubbard, Wade Jones, Lydia Henderson, Sandra Neese, Orion Cox.

Appendix

	A=	3			B=	-5			
			Random #s						
	X	Y	r1	r2	X+r1	Y+r2	Y estim		
		AX+B							
	3.9	6.7	0.085	-0.888	3.99	5.81	7.31		
	3.9	6.7	0.085	1.817	3.98	8.52	7.31		
	3	4	-0.109	0.288	2.89	4.29	4.09		
	3.2	4.6	-0.181	-0.736	3.02	3.86	4.46		
	3.3	4.9	0.083	-0.064	3.38	4.84	5.54		
	4.3	7.9	-0.243	0.466	4.06	8.37	7.52		
	4	7	-0.032	-0.611	3.97	6.39	7.26		
	4.2	7.6	0.006	-1.28	4.21	6.32	7.97		
	3.1	4.3	-0.286	-0.898	2.81	3.40	3.86		
	4.7	9.1	0.307	0.998	5.01	10.10	10.33		
	4.5	8.5	0.315	1.347	4.82	9.85	9.76		
	4.5	8.5	-0.039	-1.816	4.46	6.68	8.72		
	4	7	0.129	-0.073	4.13	6.93	7.74		
	3.6	5.8	-0.085	0.305	3.52	6.10	5.93		
	3.3	4.9	-0.121	0.915	3.18	5.82	4.93		
	4.8	9.4	0.076	-0.429	4.88	8.97	9.94		
	4.9	9.7	-0.454	0.537	4.45	10.24	8.67		
	4.6	8.8	-0.629	1.03	3.97	9.83	7.27		
	3.2	4.6	0.051	-0.722	3.25	3.88	5.15		
	4.2	7.6	-0.118	-1.747	4.08	5.85	7.60		
	3.4	5.2	0.282	0.756	3.68	5.96	6.42		
	4.4	8.2	-0.459	0.038	3.94	8.24	7.18		
	4.6	8.8	-0.199	0.695	4.40	9.50	8.54		
	4.4	8.2	-0.492	0.726	3.91	8.93	7.09		
	4.7	9.1	-0.38	0.322	4.32	9.42	8.30		
	4.3	7.9	-0.058	-0.906	4.24	6.99	8.07		
	3.5	5.5	-0.483	0.554	3.02	6.05	4.46		
	4.8	9.4	0.128	-0.748	4.93	8.65	10.10		
	3.7	6.1	-0.154	0.796	3.55	6.90	6.02		
	3	4	-0.214	-0.143	2.79	3.86	3.77		
	4.9	9.7	0.301	-0.053	5.20	9.65	10.90		
	3.7	6.1	-0.52	0.274	3.18	6.37	4.94		
	3.8	6.4	-0.464	-0.005	3.34	6.39	5.40		
	3.8	6.4	0.065	0.426	3.86	6.83	6.96		
	3.5	5.5	0.034	-0.174	3.53	5.33	5.98		
	4.1	7.3	-0.007	0.519	4.09	7.82	7.63		
	3.1	4.3	-0.526	0.56	2.57	4.86	3.15		
	3.6	5.8	0.172	1.31	3.77	7.11	6.68		
	3.4	5.2	0.535	0.684	3.93	5.88	7.17		
	4.1	7.3	0.122	0.07	4.22	7.37	8.01		

	3.95	6.85		MEAN	3.86	6.95				
	0.58	1.75		S	0.65	1.92				
	Linear Regression			Correlation						
		A=	2.41		Est A=	3.0				
		B=	-2.35		Est B=	-4.4				
					r=	0.798				
			Column 1	olumn 2	Se=	0.03				
		Column	0.423							
		Column	0.993	3.686						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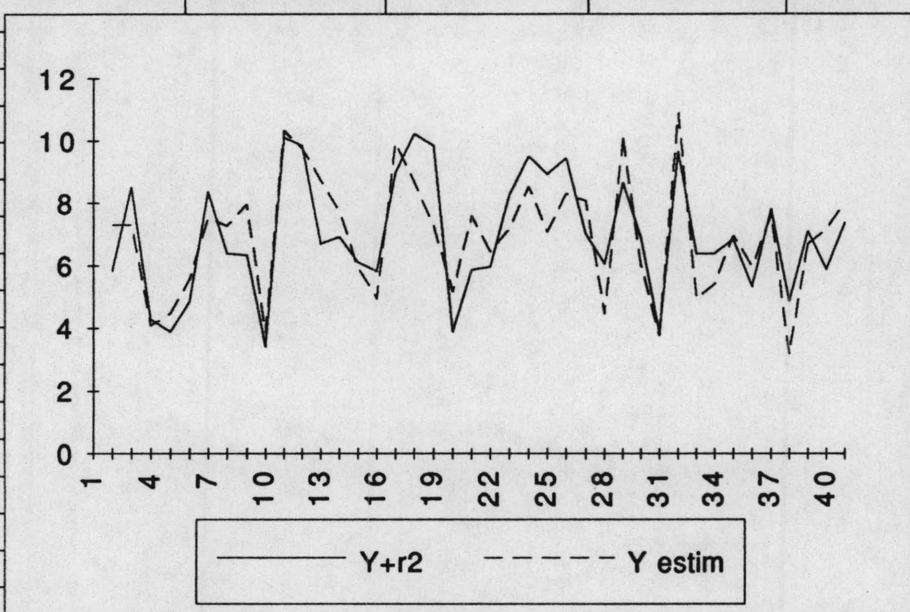
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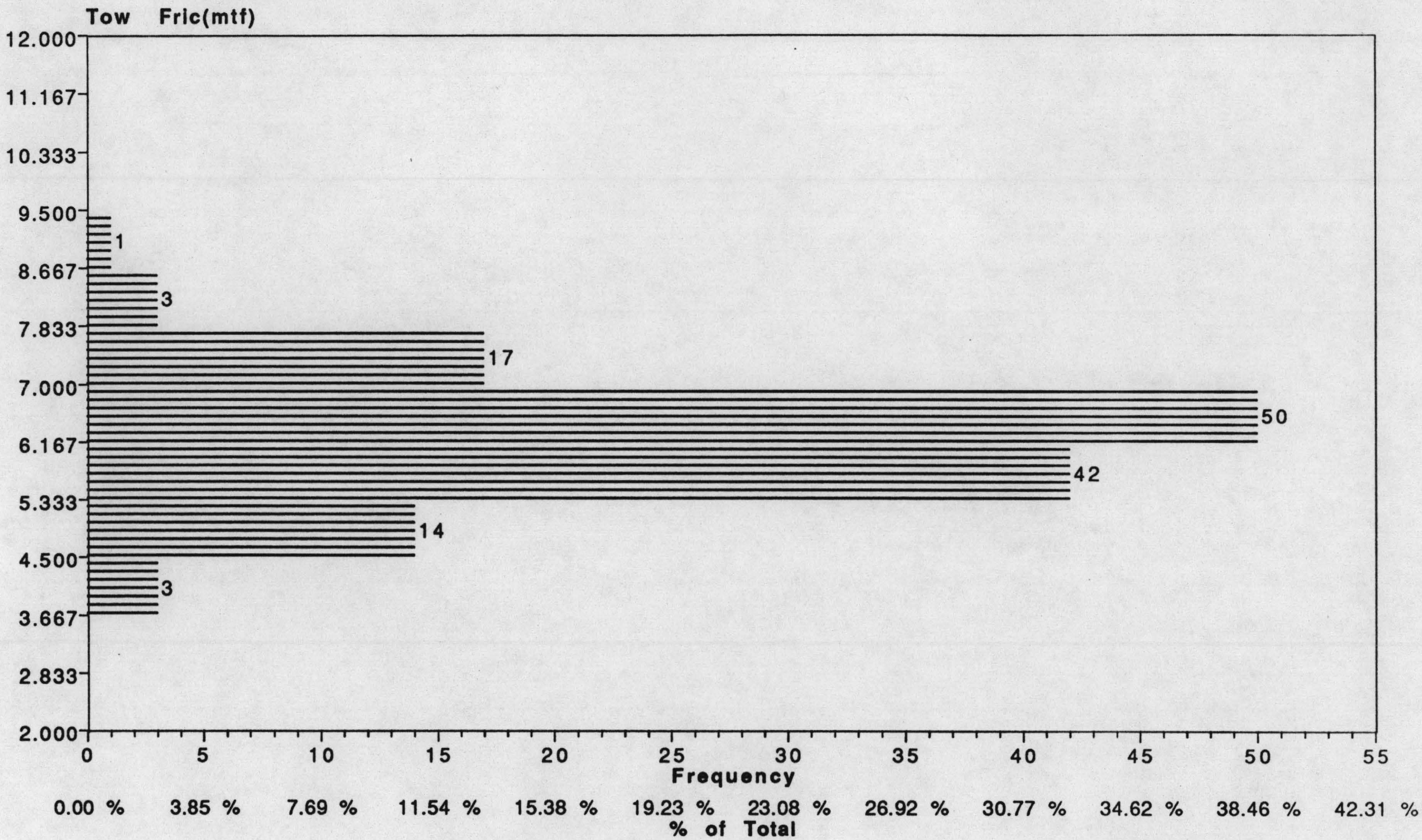
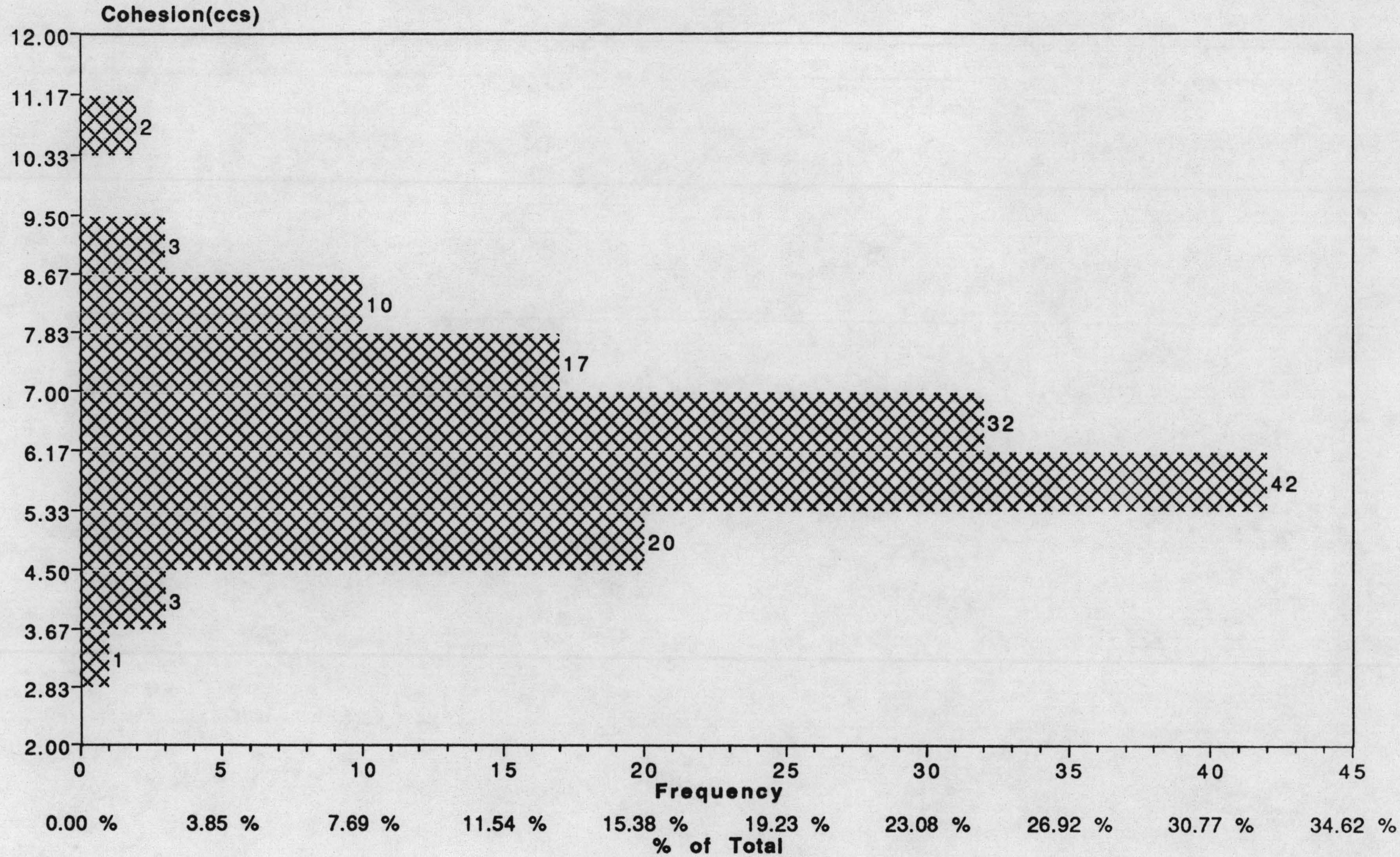


CN # 060180 Using formula ; Tow Friction = 3 Favg - 4.6
Histogram compares well to that of Cohesion.



CN # 060180 Histogram of Cohesion data collected at Decatur Plant